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(54) Chemical vapor deposition method.

(57) A CVD method comprises the steps of making a plasma self-cleaning within a chamber (2) using a gas which includes fluorine, coating an inside of the chamber by a first layer of a material which includes silicon and nitrogen, and forming a second layer on a predetermined surface within the chamber by a chemical vapor deposition. The second layer is made of a material which includes a quantity of nitrogen smaller than a quantity of nitrogen included in the first layer.

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CHEMICAL VAPOR DEPOSITION METHOD

BACKGROUND OF THE INVENTION

The present invention generally relates to chemical vapor deposition methods, and more particularly to a chemical vapor deposition method which is employed in a chemical vapor deposition apparatus of a type which makes a plasma self-cleaning using a gas which includes fluorine.

Recently, a high throughput is required of a chemical vapor deposition (CVD) apparatus. For this reason, a plasma self-cleaning is used within a chamber of the CVD apparatus so as to minimize the down time of the CVD apparatus.

In the conventional CVD apparatus, the plasma self-cleaning is made by use of a gas which includes fluorine. Thereafter, prior to forming a CVD layer on a wafer, the inside of the chamber is coated with a material identical to that of the CVD layer to a thickness of several microns so as to suppress the effects of the fluorine gas remaining within the chamber after the plasma self-cleaning.

However, in the case where the CVD layer is a SiO_2 layer or a phospho-silicate glass (PSG) layer, it is impossible to eliminate or sufficiently suppress the gas which includes CF_4, SF_6, NF_3 and the like and is used for the plasma self-cleaning. For this reason, fluorine is inevitably mixed within the SiO_2 or PSG layer which is formed on the wafer.

A description will be given of an example of a case where a SiO_2 layer is formed on a Si wafer by the CVD. First, a plasma self-cleaning is carried out using a NF_3 gas. Thereafter, prior to forming the SiO_2 layer on the Si wafer, a SiO_2 layer is coated to a thickness of 3 microns inside the chamber of the CVD apparatus. Then, the SiO_2 layer is formed on the Si wafer by the CVD.

FIG.1 shows an analysis result of a secondary ion mass spectrometry (SIMS) which is made with respect to the SiO_2 layer which is formed on the Si wafer by the CVD. As may be seen from FIG.1, fluorine of a high concentration is mixed into the SiO_2 layer.

Therefore, according to the conventional CVD method, there are problems in that fluorine mixes into the SiO_2 layer, PSG layer and the like which are formed on the wafer by the CVD and the quality of the layer deteriorates.

SUMMARY OF THE INVENTION

Accordingly, it is a general object of the present invention to provide a novel and useful CVD method in which the problems described above are eliminated.

Another and more specific object of the present invention is to provide a CVD method comprising the steps of making a plasma self-cleaning within a chamber using a gas which includes fluorine, coating an inside of the chamber by a first layer of a material which includes silicon and nitrogen, and forming a second layer on a predetermined surface within the chamber by a chemical vapor deposition, where the second layer is made of a material other than nitrogen. According to the CVD method of the present invention, the inside of the chamber is coated by the first layer so as to positively eliminate or suppress the fluorine gas remaining within the chamber after the plasma self-cleaning. For this reason, the amount of fluorine mixed into the second layer is substantially suppressed compared to the conventional CVD method. The impurity quantity within the second layer is extremely small, and the second layer is uniform.

Other objects and further features of the present invention will be apparent from the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is shows an analysis result of a SIMS which is made with respect to a SiO_2 layer which is formed by a conventional CVD method;

FIG.2 is a diagram generally showing a plasma CVD apparatus which is used to carry out a CVD method according to the present invention;

FIG.3 shows an analysis result of SIMS which is made with respect to a SiO_2 layer which is formed by a second embodiment of the CVD method according to the present invention;

FIG.4 shows an analysis result of SIMS which is made with respect to a PSG layer which is formed by a second embodiment of the CVD method according to the present invention; and

FIGS.5 through 7 show analysis results of SIMS which is made with respect to a PSG layer which is formed by a conventional CVD method.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG.2 generally shows a plasma CVD apparatus which is used to carry out a CVD method according to the present invention. For the sake of convenience, it is assumed that a SiO_2 layer is formed on a Si wafer by use of the plasma CVD apparatus shown in FIG.2 in a first embodiment of

the CVD method according to the present invention. The plasma CVD apparatus generally comprises an RF source 1, a chamber 2, an RF electrode 3, a stage 4, and a valve group 5. A Si wafer 10 is placed on the stage 4 within the chamber 2.

First, a plasma self-cleaning is made as follows. That is, a pressure within the chamber 2 is set to 0.5 Torr, and a NF_3 gas is supplied at a flow rate of 100 cc/min. The RF source 1 operates at an RF of 13.56 MHz and 300 W.

Second, the pressure within the chamber 2 is set to 1 Torr, and a SiH_4 gas is supplied at a flow rate of 20 cc/min, a NH_3 gas is supplied at a flow rate of 100 cc/min and a N_2 gas is supplied at a flow rate of 200 cc/min. The RF source 1 operates at an RF of 13.56 MHz and 300 W. As a result, a plasma SiN layer coats the inside of the chamber 2 with a thickness of 0.3 micron.

Third, the Si wafer 10 is placed on the stage 4 within the chamber 2, and the pressure within the chamber 2 is set to 1 Torr. The wafer temperature is set to 400° C. In addition, a SiH_4 gas is supplied at a flow rate of 5 cc/min, a N_2O gas is supplied at a flow rate of 250 cc/min and a N_2 gas is supplied at a flow rate of 50 cc/min. The RF source 1 operates at an RF of 13.56 MHz and 300 W. As a result, a SiO_2 layer having a thickness of 1 micron is formed on the Si wafer 10.

FIG.3 shows an analysis result of a SIMS which is made with respect to the SiO_2 layer which is formed on the Si wafer 10 by this embodiment. It can be seen from a comparison of FIGS.3 and 1 that in this embodiment the amount of fluorine mixed into the SiO_2 layer which is formed on the Si wafer 10 is extremely small compared to that of the conventional case.

Next, a description will be given of a second embodiment of the CVD method according to the present invention. In this embodiment, a PSG layer is formed on the Si wafer by use of the plasma CVD apparatus shown in FIG.2.

First, a plasma self-cleaning is made for 80 seconds under the following conditions. That is, a pressure within the chamber 2 is set to approximately 0.5 Torr, and a NF_3 gas is supplied at a flow rate of 300 SCCM and N_2O gas is supplied at a flow rate of 150 SCCM. The RF source 1 operates at an RF of 13.56 MHz and 500 W. The temperature within the chamber 2 is set to 350° C.

Second, a SiN layer is coated inside the chamber 2 for 15 seconds under the following conditions. That is, the pressure within the chamber 2 is set to 3 Torr, and a SiH_4 gas is supplied at a flow rate of 130 SCCM, a NH_3 gas is supplied at a flow rate of 60 SCCM and a N_2 gas is supplied at a flow rate of 500 SCCM. The RF source 1 operates at an RF of 13.56 MHz and 350 W. The temperature within the chamber 2 is set to 350° C. As a result, the plasma SiN layer coats the inside of the chamber 2 with a thickness of approximately 1500 Å.

Third, the Si wafer 10 is placed on the stage 4 within the chamber 2, and the pressure within the chamber 2 is set to 3 Torr. The wafer temperature is set to 350° C. In addition, a SiH_4 gas is supplied at a flow rate of 50 SCCM, a N_2O gas is supplied at a flow rate of 1300 SCCM and a gas which includes 1% of PH_3 gas within an Ar gas is supplied at a flow rate of 800 SCCM. The RF source 1 operates at an RF of 13.56 MHz and 100 W. This process is carried out for 15 seconds. As a result, a PSG layer having a thickness of approximately 2000 Å is formed on the Si wafer 10.

FIG.4 shows an analysis result of a SIMS which is made with respect to the PSG layer which is formed on the Si wafer 10 by this embodiment. It can be seen from FIG.3 that the amount of fluorine mixed into the PSG layer which is formed on the Si wafer 10 is extremely small.

For comparison purposes, FIGS.5 through 7 show analysis results of SIMS which is made with respect to a PSG layer which is formed by a conventional CVD method. According to the conventional CVD method, it is assumed that a plasma self-cleaning and the forming of the PSG layer on the Si wafer are made under the same conditions as those of the second embodiment. But according to the conventional CVD method, a PSG layer coats the inside of the chamber after the plasma self-cleaning and prior to the forming of the PSG layer on the Si wafer. The PSG layer coats the inside of the chamber under the following conditions. That is, the pressure within the chamber is set to 3 Torr. The wafer temperature is set to 350° C. In addition, a SiH_4 gas is supplied at a flow rate of 40 SCCM, a N_2O gas is supplied at a flow rate of 1300 SCCM and a PH_3 gas is supplied at a flow rate of 800 SCCM. The RF source operates at an RF of 13.56 MHz and 100 W. This process is carried out for 15 seconds, 30 seconds and 60 seconds.

FIGS.5, 6 and 7 respectively, show analysis results of SIMS which is made with respect to the PSG layer which is formed by the conventional CVD method for the three cases where the process of forming the PSG layer within the chamber is carried out for 15 seconds, 30 seconds and 60 seconds. It can be seen from FIGS.5 through 7 that the amount of fluorine mixed into the PSG layer which is formed on the Si wafer is relatively large regardless of the length of the process of forming the PSG layer within the chamber. But as may be seen by comparing FIG.4 with FIGS.5 through 7, the amount of fluorine mixed into the PSG layer which is formed on the Si wafer 10 according to the second embodiment is extremely small com-

pared to the conventional case.

The effect of reducing the amount of fluorine mixed into the layer which is formed on the wafer by the CVD method is notable when the inside of the chamber is coated with a layer which includes silicon (Si) and nitrogen (N) to a thickness of at least 1000 Å.

In addition, the layer which coats the inside of the chamber may be selected from a group of materials including SiN, SiON and SiBN.

Further, the present invention is not limited to these embodiments, but various variations may be made without departing from the scope of the present invention.

Claims

1. A chemical vapor deposition method comprising the step of making a plasma self-cleaning within a chamber (2) using a gas which includes fluorine, characterized in that there are further provided the steps of: coating an inside of the chamber (2) by a first layer of a material which includes silicon and nitrogen; and forming a second layer on a predetermined surface within the chamber by a chemical vapor deposition, said second layer being made of a material which includes a quantity of nitrogen smaller than a quantity of nitrogen included in said first layer.

2. The chemical vapor deposition method as claimed in claim 1, characterized in that said step of making the plasma .self-cleaning uses a NF_3 gas.

3. The chemical vapor deposition method as claimed in claim 1 or 2, characterized in that said step of coating the inside of the chamber (2) coats the first layer which is made of a material selected from a group of materials including SiN, SiON and SiBN.

4. The chemical vapor deposition method as claimed in any of claims 1 to 3, characterized in that said step of forming the second layer forms the second layer from a material selected from a group of materials including silicon dioxide (SiO_2) and phospho-silicate glass (PSG).

5. The chemical vapor deposition method as claimed in claim 4, characterized in that said predetermined surface is made of silicon (Si).

6. The chemical vapor deposition method as claimed in any of claims 1 to 5, characterized in that said step of coating the inside of the chamber (2) coats the first layer to a thickness of at least 1000 Å.

7. The chemical vapor deposition method as claimed in claim 1, characterized in that said second layer is made of a material which includes no nitrogen.

FIG. 1 PRIOR ART

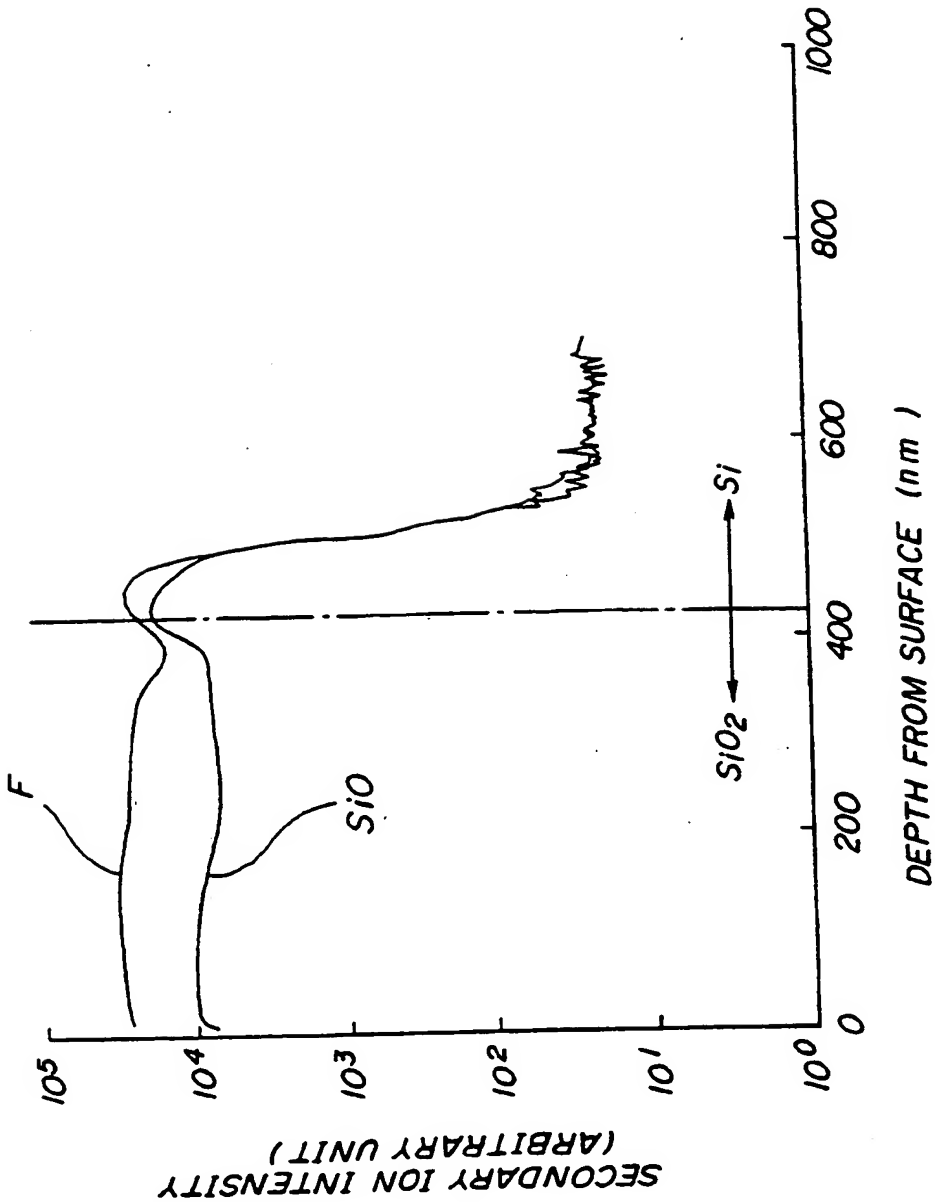
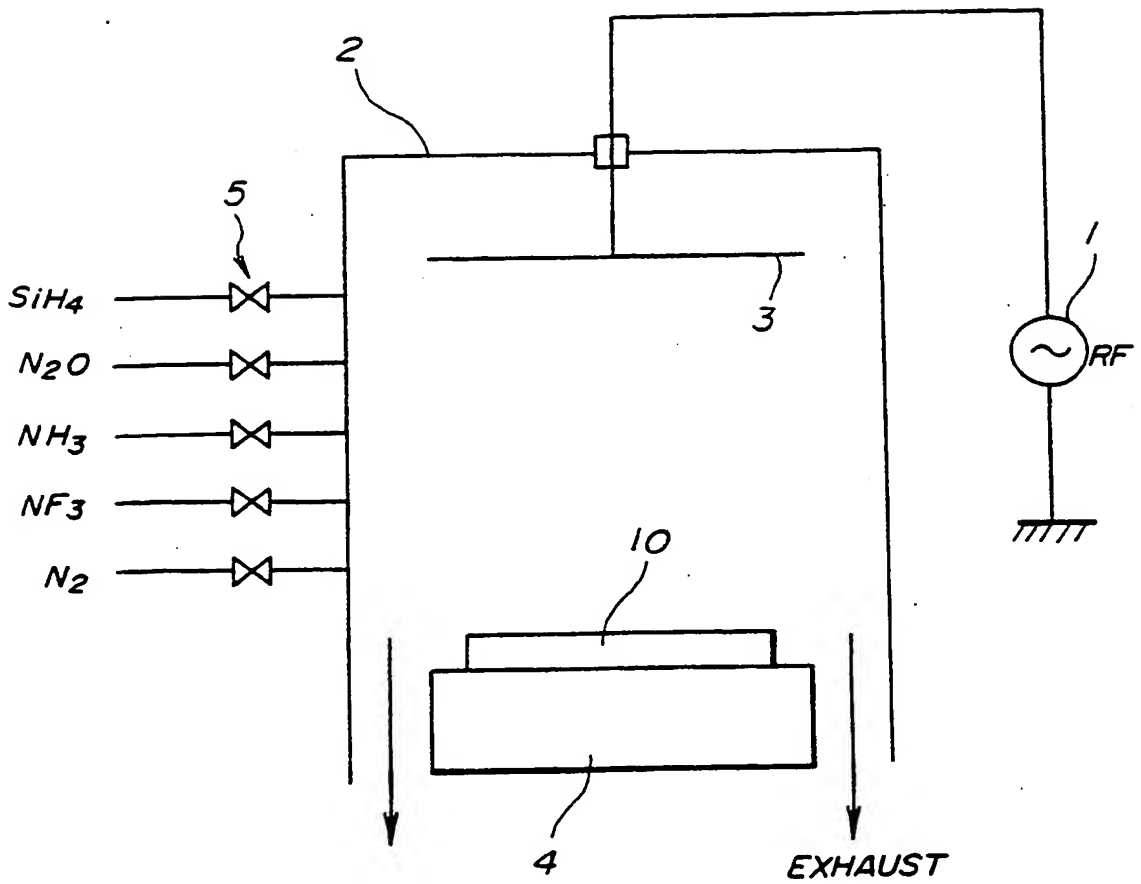


FIG. 2



FIG, 3

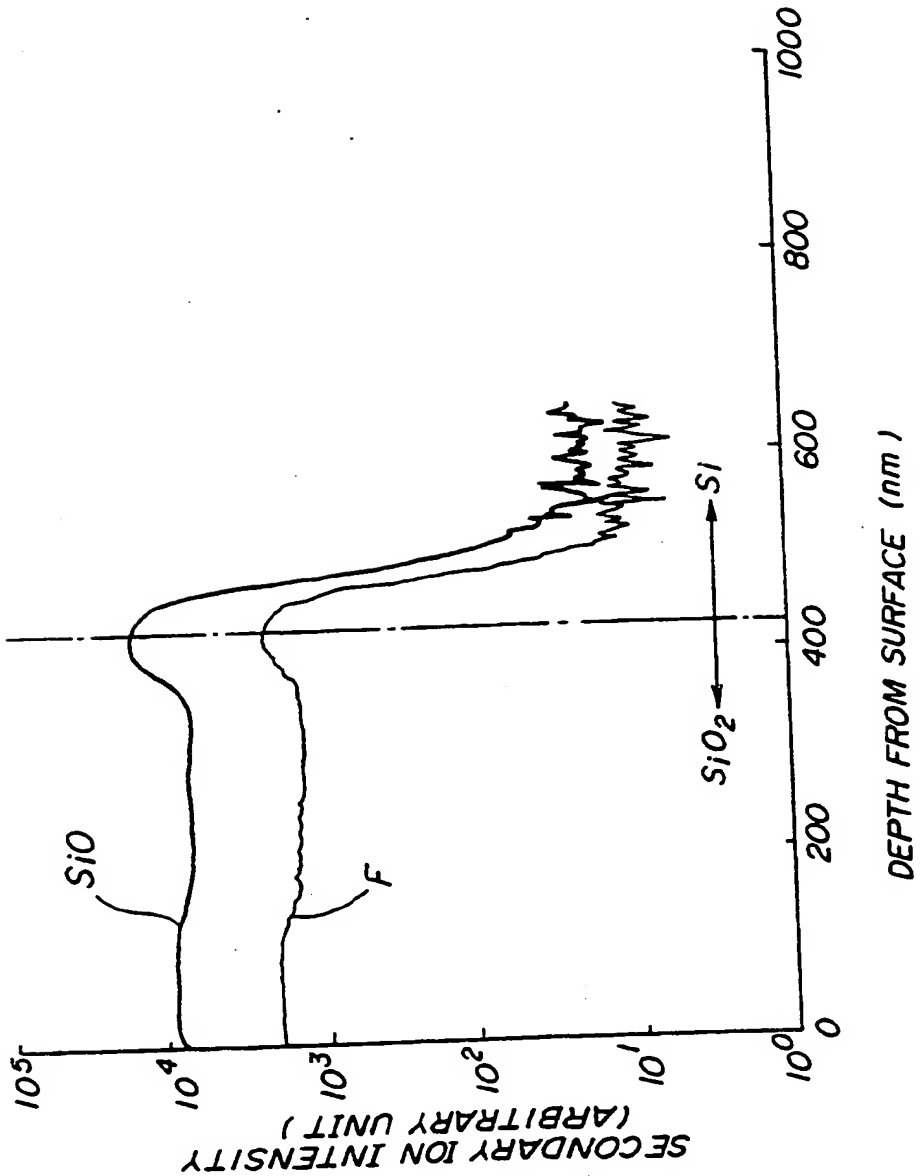


FIG. 4

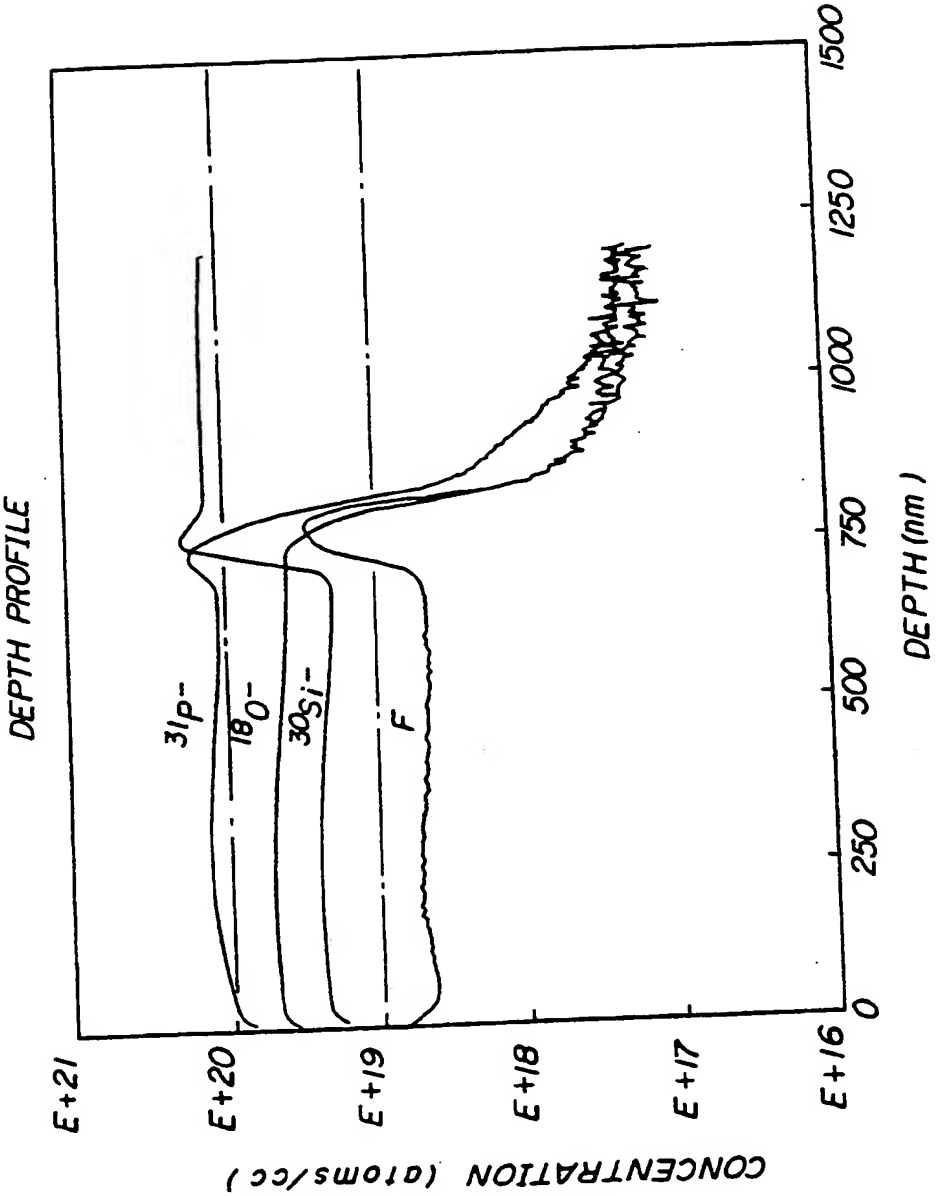

DEPTH PROFILE
$^{31}P^-$
$^{18}O^-$
$^{30}Si^-$
F
E+21
E+20
E+19
E+18
E+17
E+16
CONCENTRATION (atoms/cc)
0
250
500
750
1000
1250
1500
DEPTH (nm)

FIG.5 PRIOR ART

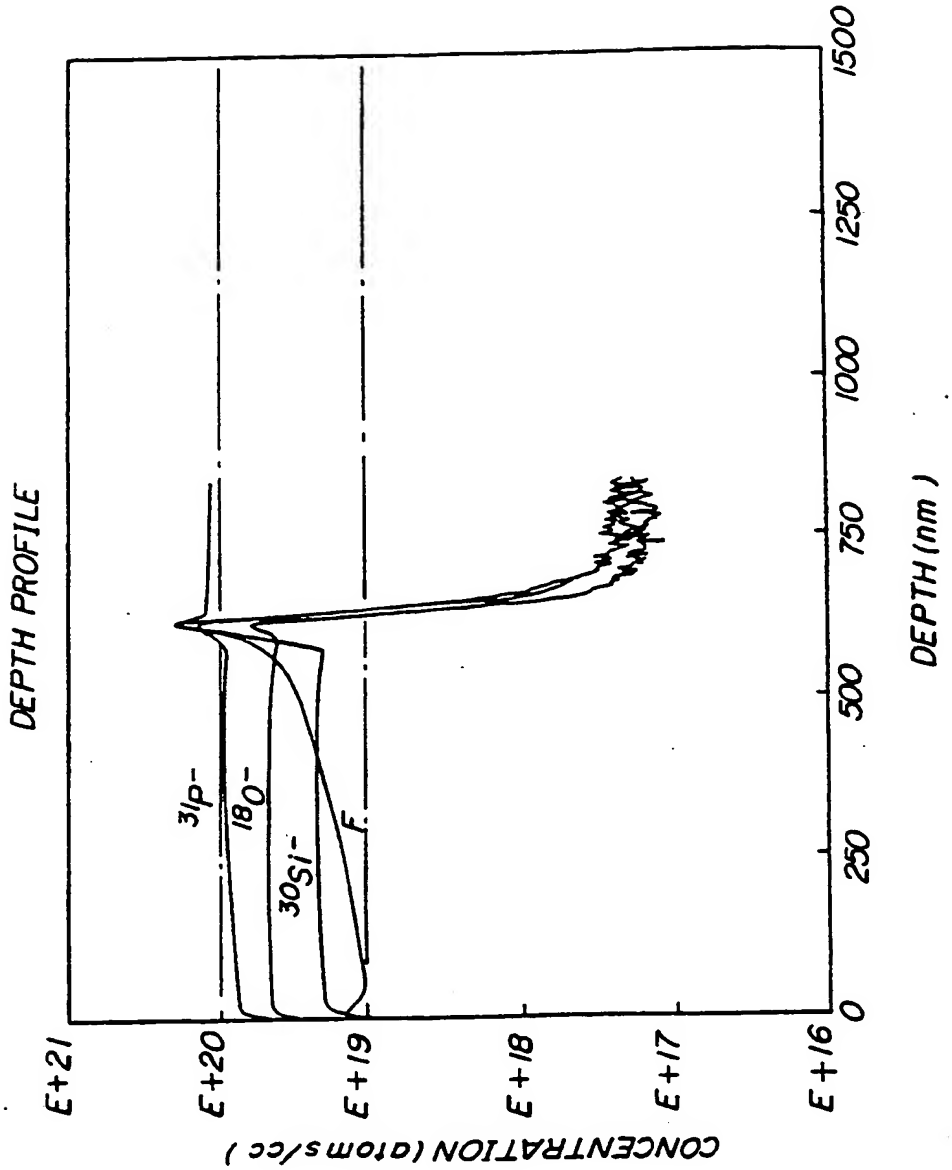


FIG.6 PRIOR ART

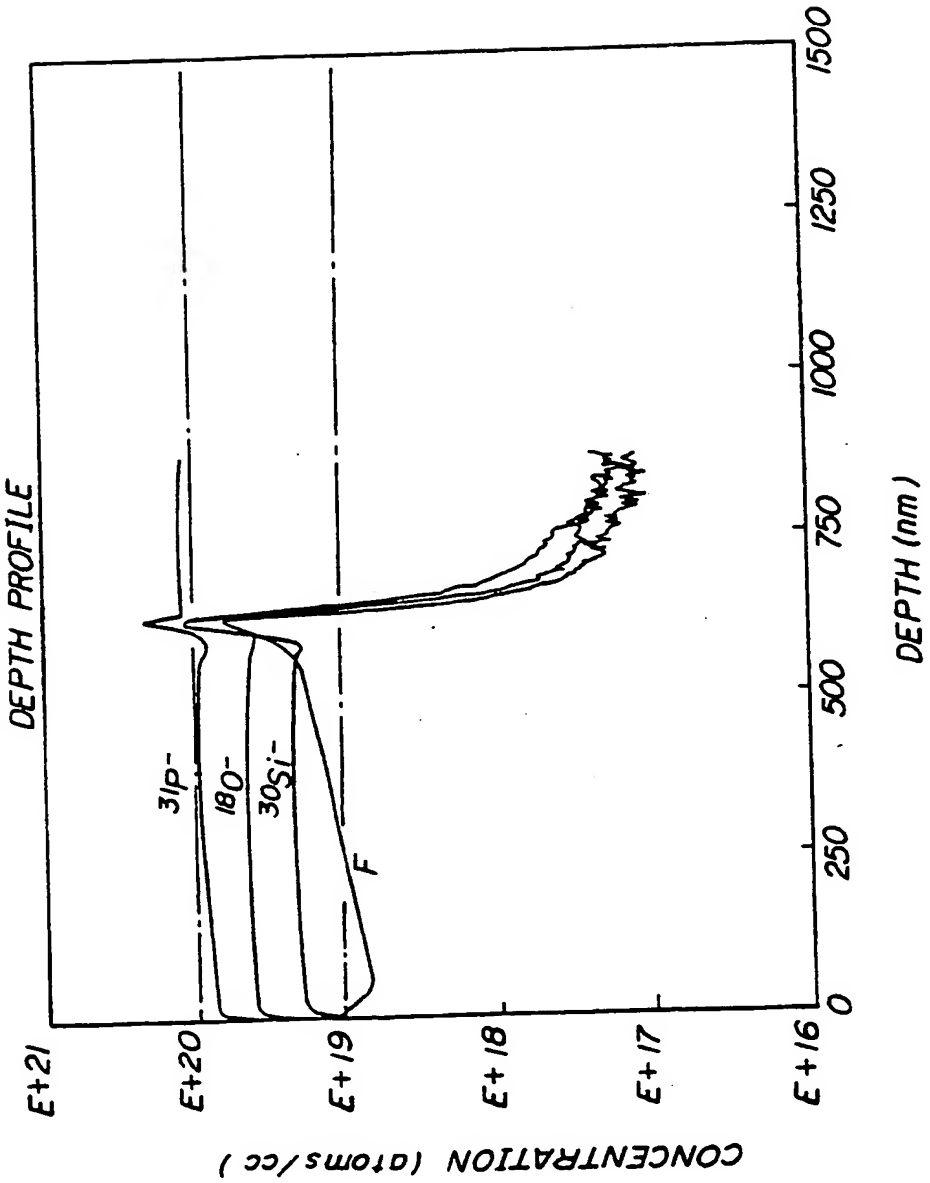
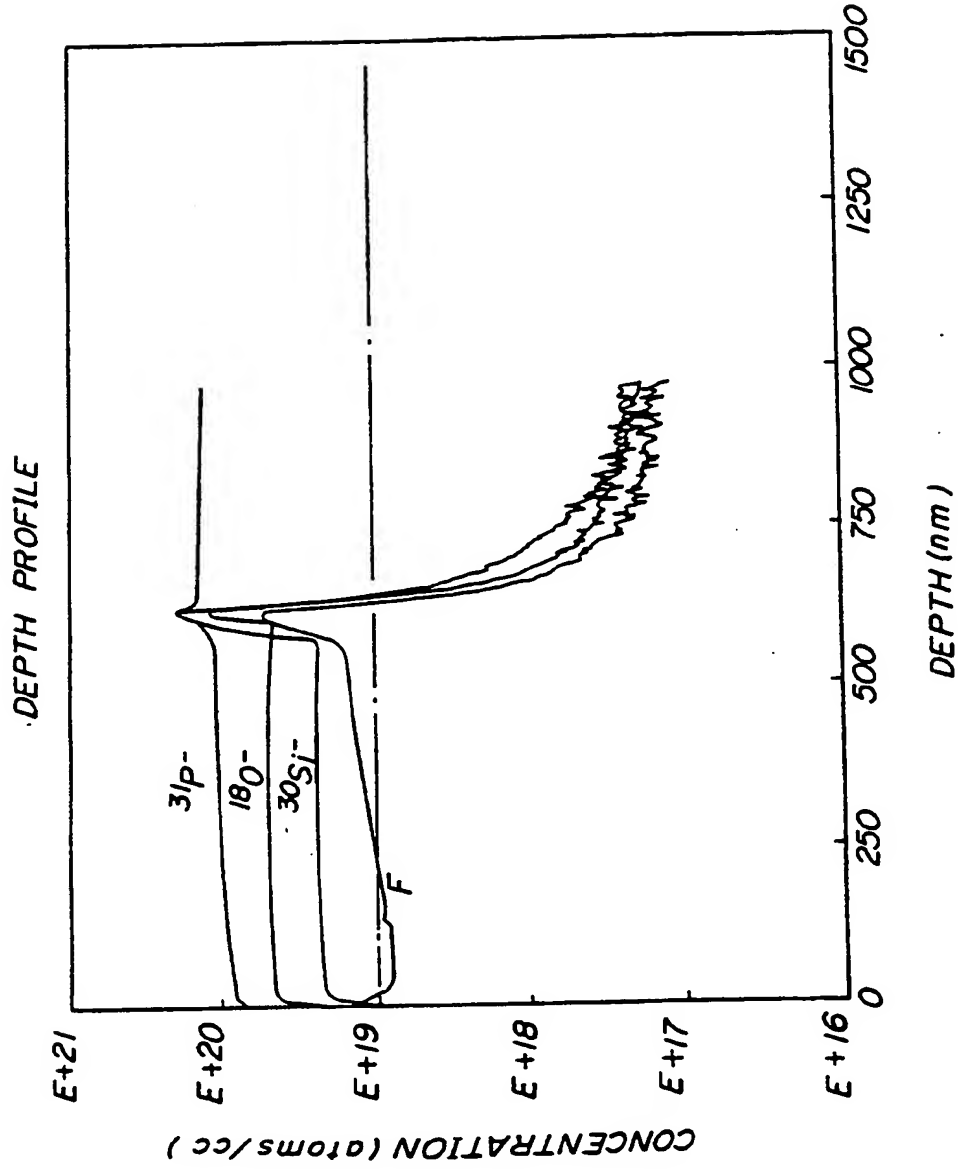


FIG.7 PRIOR ART



European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 90104203.6

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl.)
A	EP - A2 - 0 296 891 (APPLIED MATERIALS) * Claims 1,6,7; page 8, line 25 - page 9, line 60 *	1,2,5	C 23 C 16/44
A	DE - A1 - 3 035 379 (NAAMLOZE NENNOOTSCHAP PHILIPS') * Claim 1; example *	1	

TECHNICAL FIELDS SEARCHED (Int Cl.)

C 23 C 16/00
C 23 G 5/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	29-05-1990	KÖRBER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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